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(54) **SUBSTITUTED QUINAZOLINES, THE PREPARATION THEREOF AND THE USE THEREOF IN PHARMACEUTICAL COMPOSITIONS**

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(57) **ABSTRACT**

The present invention relates to substituted quinazolines of formula (I) wherein X and Y are defined as in claim **1**, the tautomers, stereoisomers, mixtures and salts thereof, which have valuable pharmacological properties, particularly an inhibitory effect on the activity of the enzyme dipeptidylpeptidase-IV (DPP-IV).

10 Claims, No Drawings

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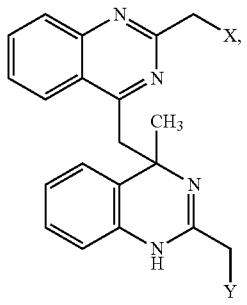
SUBSTITUTED QUINAZOLINES, THE PREPARATION THEREOF AND THE USE THEREOF IN PHARMACEUTICAL COMPOSITIONS

The present invention provides substituted quinazolines of formula (I)



(I)

wherein the groups X and Y are as defined hereinafter, including the tautomers, stereoisomers (e.g. enantiomers, diastereomers), mixtures and salts thereof, particularly the physiologically acceptable salts thereof with inorganic or organic acids, which have interesting properties. For example, they have pharmacological properties such as e.g. an inhibitory effect on the activity of the enzyme dipeptidylpeptidase-IV (DPP-IV) and can be used in the in the pharmaceutical industry for the production of pharmaceutical compositions for use in human and/or veterinary medicine.

The present invention relates to the compounds of formula (I), the tautomers, stereoisomers (e.g. enantiomers, diastereomers), mixtures and salts thereof, the preparation thereof, the use thereof for the prevention or treatment of disorders or conditions which are connected with an increased DPP-IV activity or which can be prevented or alleviated by reducing the DPP-IV activity, particularly type I or type II diabetes mellitus, the pharmaceutical compositions containing a compound of formula (I) or a physiologically acceptable salt thereof as well as processes for the preparation thereof.

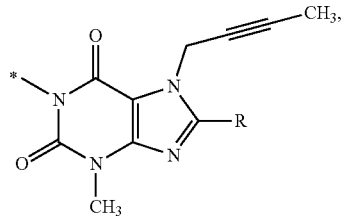
The invention further relates to pharmaceutical compositions or combinations comprising one or more such compounds of the invention and, optionally, one or more further active substances, as well as to the preparation and use thereof.

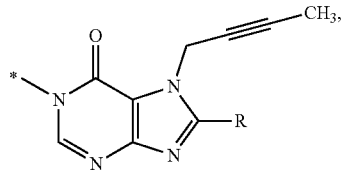
The invention further relates to the use of compounds, pharmaceutical compositions or combinations according to this invention for preparing medicaments, particularly for preparing medicaments for the treatment and/or prevention of metabolic diseases, especially type 2 diabetes mellitus and/or conditions related thereto (e.g. diabetic complications). Further, the invention relates to compounds according to the invention, pharmaceutical compositions or combinations comprising such active ingredients, for use in methods of inhibiting DPP-IV and/or of treating and/or preventing diseases, disorders or conditions as described herein.

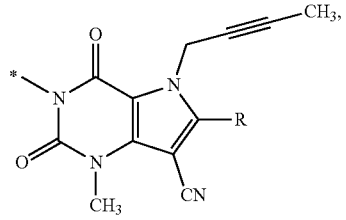
Further, the invention relates to a method of treating and/or preventing diseases, disorders or conditions as described herein, said method comprising administering an effective amount of a compound according to the invention, or a pharmaceutical composition or combination comprising such compound, to the patient (particularly human patient) in need thereof.

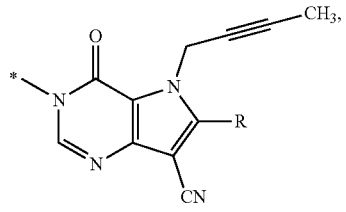
The compounds of formula (I) shown above include the tautomers, stereoisomers (e.g. enantiomers, diastereomers), mixtures and salts thereof wherein X, Y, R, R1 and R2 are defined as follows:

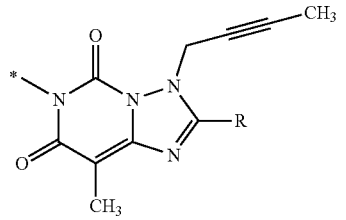
In an embodiment of the invention, X and Y are the same or different and are independently selected from the following:



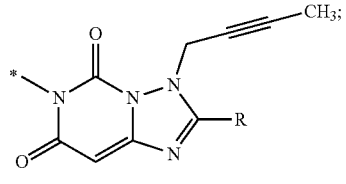








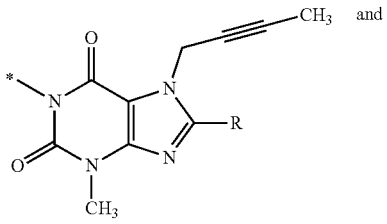
and



and

each R is independently selected from R1 and R2, in which R1 and R2 are the same or different and are independently selected from 3-amino-piperidin-1-yl, (2-amino-2-methyl-propyl)-methylamino and (2-amino-propyl)-methylamino.

In a further embodiment of the invention, X and Y are the same or different and are independently selected from



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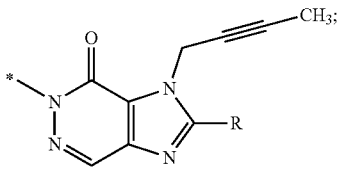


and

each R is independently selected from R1 and R2, in which

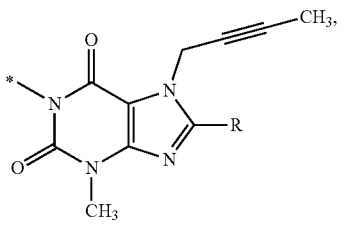
R1 and R2 are the same or different and are independently selected from 3-amino-piperidin-1-yl, (2-amino-2-methyl-propyl)-methylamino and (2-amino-propyl)-methylamino.

In certain embodiments, R1 and R2 are the same or different and are independently selected from 3-(R)-amino-piperidin-1-yl, (2-amino-2-methyl-propyl)-methylamino and (2-(S)-amino-propyl)-methylamino.

In certain embodiments, R1 and R2 are the same.

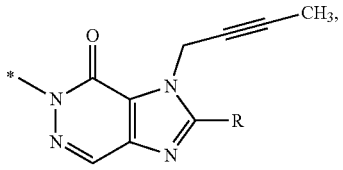
In certain embodiments, R1 and R2 are the same and are selected from 3-(R)-amino-piperidin-1-yl, (2-amino-2-methyl-propyl)-methylamino and (2-(S)-amino-propyl)-methylamino. Preferably, R1 and R2 are the same and are each 3-(R)-amino-piperidin-1-yl.

In certain embodiments, X and Y are the same or different and are each the following radical:



in which each R is independently selected from 3-amino-piperidin-1-yl, (2-amino-2-methyl-propyl)-methylamino and (2-amino-propyl)-methylamino.

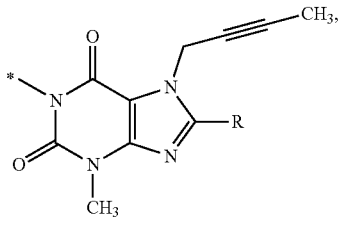
In certain embodiments, X and Y are the same or different and are each the following radical:



in which each R is independently selected from 3-amino-piperidin-1-yl, (2-amino-2-methyl-propyl)-methylamino and (2-amino-propyl)-methylamino.

In certain embodiments, X and Y are the same.

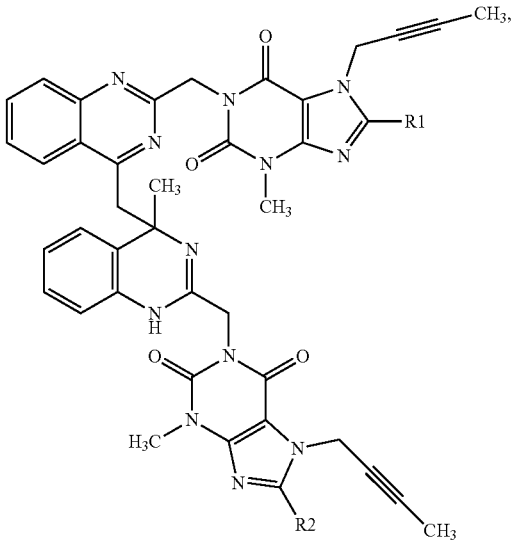
Preferably, X and Y are the same and are each the following radical:



in which R is 3-(R)-amino-piperidin-1-yl.

In a particular embodiment, the present invention relates to a compound of formula (IB):

(IB)



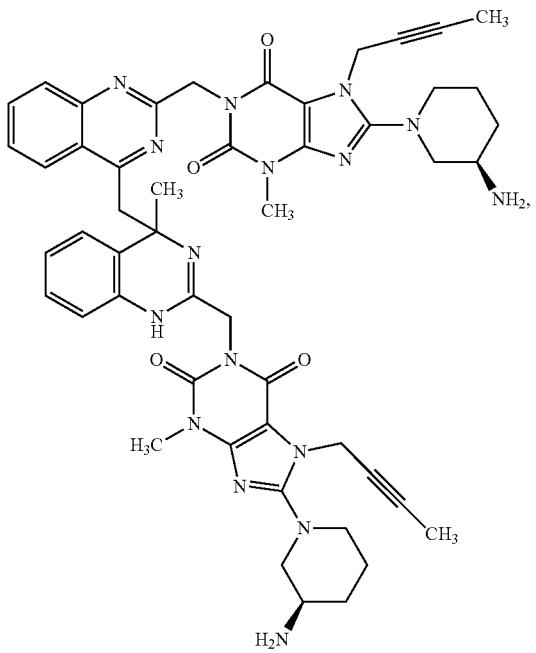
wherein R1 and R2 are as defined above,

or a tautomer, stereosiomer (e.g. enantiomer or diastereomer), mixture or salt thereof.

In a further particular embodiment, the present invention relates to a compound of formula (IB), wherein R1 and R2 are the same and are as defined above, or a tautomer, stereosiomer (e.g. enantiomer or diastereomer), mixture or salt thereof.

Preferred is the compound of following formula (IA):

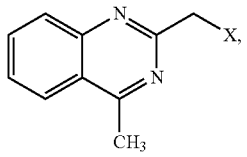
(IA)



or a tautomer, stereosiomer (e.g. enantiomer or diastereomer), mixture or salt thereof.

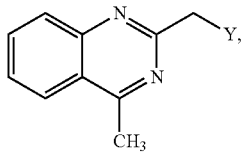
The compounds of formula (I) may be obtained by methods known per se, for example by the following method comprising reacting a compound of formula (II)

(II)



wherein X is as hereinbefore defined, with a compound of formula (II')

(II')



wherein Y is as hereinbefore defined,
preferably in the presence of a suitable acid, for example HCl, such as e.g. aqueous hydrochloric acid, or an other suitable inorganic or organic acid.

This reaction may be conducted in a suitable reaction medium (or mixture of media).

Optionally, such method of preparing may further comprise:
Subsequently, if desired, any protecting groups used during the reaction are cleaved and/or the compounds of formula (I) thus obtained are resolved into their stereosiomers (e.g. enantiomers or diastereomers) and/or
the compounds of formula (I) thus obtained are converted into the salts thereof, particularly for pharmaceutical use into the physiologically acceptable salts thereof with inorganic or organic acids or bases.

Compounds of formula (I) according to this invention may be reversibly dissociable into the compounds of formulae (II) and (II'), in which X and Y are as herein defined. Such dissociation of a compound of formula (I) into its monomers can be obtained under acidic conditions, for example in the presence a suitable acid, for example HCl, such as e.g. aqueous hydrochloric acid, or an other suitable inorganic or organic acid.

This reaction may be conducted in a suitable reaction medium (or mixture of media).

The compounds of formulae (II) or (II') shown above may include the tautomers, stereoisomers (e.g. enantiomers, diastereomers), mixtures and salts thereof, as well as solvates thereof, wherein X and Y are defined as disclosed herein.

In an embodiment, the preparation of compounds of formula (I) from compounds of formula (II) and/or compounds of formula (II') (e.g. by dimerization) is conducted in the presence of a suitable solvent or mixture of solvents. For example, such a reaction solvent is a polar solvent or mixture of polar solvents or a polar solvent system, such as e.g. water or an aqueous medium. In another embodiment, such reaction is conducted in a solvent-free medium. In a further embodiment, the compounds of formula (I) are isolated or obtained from a suitable solvent or mixture of solvents.

In another embodiment, the preparation of compounds of formulae (II) or (II') from compounds of formula (I) (e.g. by dissociation) is conducted in the presence of a suitable solvent or mixture of solvents. For example, such a reaction solvent is a polar solvent or mixture of polar solvents or a polar solvent system, such as e.g. water or an aqueous medium. In another embodiment, such reaction is conducted in a solvent-free medium. In a further embodiment, the compounds of formulae (II) or (II') are isolated or obtained from a suitable solvent or mixture of solvents.

Above-mentioned methods of preparation may be conducted in a suitable solvent, or mixture of solvents. The compounds of formulae (I), (II) or (II'), or their salts, thus obtainable may be isolated from such solvent or mixture of solvents (e.g. either in crystalline or amorphous form) in a manner customary per se. Optionally, purification, chromatographic separation, slurrying, suspending, dissolving, crystallization, precipitating (e.g. with a non-solvent, anti- or poor solvent), filtration, washing, lyophilization, or the like of the compounds of formulae (I), (II) or (II'), or salts thereof, may be performed, e.g. in the presence of one or more suitable solvents or mixture of solvents. Subsequently, optionally the solvent or mixture of solvents may be removed (e.g. evaporated) or the solid material may be collected or isolated, e.g. in order to obtain the compounds of formulae (I), (II) or (II'), or salts thereof, e.g. in isolated, pure, precipitated, solid (e.g. crystalline or amorphous), lyophilized, etc. form. Such steps may be optionally conducted at lower, ambient or elevated temperature. Optionally such procedures may be repeatedly and/or alternately applied to the obtained material. Further optionally, such procedures may be conducted independently or dependently from the foregoing preparation step(s). Further optionally, the obtained material may be dried (e.g. at elevated temperature). In an embodiment, the material may be spray-, freeze- or drum dried. In a further embodiment the material may be in isolated, precipitated, crystallized, lyophilized, amorphous or solid form. In another embodiment the material may be in solution or suspension form. In a yet

further embodiment the material may be in salt or free form. In a still yet further embodiment the material may be in crude or purified form.

In general, solvents or solvent systems, which the skilled person may consider within such procedures of the invention, may include, without being limited to, organic, non-aqueous or aqueous, protic or aprotic, polar or apolar solvents, such as, for example, ketones such as e.g. acetone, methyl ethyl ketone, methyl propyl ketone, methyl tert- or isobutyl ketone, or the like, lactones such as e.g. valerolactone, ethers such as e.g. diethyl ether, diisopropyl ether, methyl tert-butyl ether, ethylene glycol, tetrahydrofuran, methyl tetrahydrofuran, dioxane, or the like, hydrocarbons such as e.g. toluene, hexane, cyclohexane, methylcyclohexane, or the like, chlorinated hydrocarbons such as e.g. methylene chloride, 1,2-dichloroethane, chloroform, chlorobenzene, or the like, low-molecular-weight aliphatic alcohols such as e.g. methanol, ethanol, 1-propanol, isopropanol, butanol, tert-amylalkohol, or the like, esters such as e.g. acetic acid lower alkyl esters (e.g. ethyl acetate) or the like, amides or lactames such as e.g. N,N-dimethylformamide, N-methyl-2-pyrrolidone, N,N-dimethylacetamide, N-methylacetamide, or the like, nitriles such as e.g. acetonitrile, or the like, or sulfoxides such as e.g. DMSO, or the like, amines, e.g. triethylamine pyridine, or the like, or water, or mixtures thereof.

Examples of acids, in the presence of which the formation and/or dissociation of a compound of formula (I) may be conducted, may include, without being limited to, strong inorganic or organic acids (which may be of Bronsted and/or Lewis acid type, and/or which may be in solid, liquid or gas form), for example HCl, such as e.g. aqueous hydrochloric acid, or the like. Further, optionally, the formation and/or dissociation of a compound of formula (I) may be conducted under any other suitable acidic conditions, acidic medium or acidic milieu.

In a particular embodiment, the preparation of compounds of formula (I) from compounds of formula (II) and/or compounds of formula (II') is conducted in a polar solvent or mixture of polar solvents. In a further embodiment, the compounds of formula (I) are obtained or isolated from a polar solvent or mixture of polar solvents.

For example, such a suitable solvent within the meaning of this invention is water or an aqueous medium.

Another example of such a solvent or solvent system within the meaning of this invention may include or consist (essentially) of water or an aqueous medium, a low-molecular-weight aliphatic alcohol or such an alcoholic medium, or a mixture thereof.

The present invention further relates to the compounds of formulae (I), (II) or (II'), the tautomers, enantiomers, diastereomers, mixtures or salts thereof or solvates thereof, including in any form, each as obtainable or obtained according to a procedure as disclosed herein.

It is moreover known to the person skilled in the art that if there are a number of reactive centers on a starting or intermediate compound it may be necessary to block one or more reactive centers temporarily by protective groups in order to allow a reaction to proceed specifically at the desired reaction center. A detailed description for the use of a large number of proven protective groups is found, for example, in "Protective Groups in Organic Synthesis" by T. Greene and P. Wuts (John Wiley & Sons, Inc. 1999, 3rd Ed.) or in "Protecting Groups (Thieme Foundations Organic Chemistry Series N Group" by P. Kocienski (Thieme Medical Publishers, 2000).

For example, protecting groups for an amino, alkylamino or imino group may be, for example, a formyl, acetyl, trifluoroacetyl, methoxycarbonyl, ethoxycarbonyl, tert.-butoxycarbonyl or phthalimido group.

The cleaving of a tert.-butyloxycarbonyl group is preferably carried out by treating with an acid such as trifluoroacetic acid or hydrochloric acid, optionally using a solvent such as methylene chloride, dioxane, methanol, ethanol, isopropanol or diethyl ether.

A formyl, acetyl, methoxycarbonyl, ethoxycarbonyl or trifluoroacetyl group is preferably cleaved by treating with an acid such as hydrochloric acid, optionally in the presence of a solvent such as acetic acid, at temperatures between 20 and 120° C. or by treating with sodium hydroxide solution, optionally in the presence of a solvent such as tetrahydrofuran, methanol or ethanol, at temperatures between 0 and 100° C.

A phthaloyl group is preferably cleaved in the presence of hydrazine or a primary amine such as methylamine, ethylamine, ethanolamine or n-butylamine in a solvent such as methanol, ethanol, isopropanol, toluene/water, dioxane or tetrahydrofurane, with or without water, at temperatures between 20° C. and the reflux temperature of the reaction mixture.

Salts of the compounds according to the present invention include—depending upon their nature—all acid addition salts and all salts with bases, especially all pharmaceutically acceptable acid addition salts and salts with bases. Particular mention may be made of the physiologically tolerable salts with inorganic or organic acids or bases customarily used in pharmacy. The salts include water-insoluble and, particularly, water-soluble salts.

Inorganic acids which may be suitable for forming pharmaceutically or physiologically acceptable acid addition salts include, by way of example and not limitation, hydrochloric acid, hydrobromic acid, phosphoric acid, sulfuric acid, and the like. Organic acids which may be suitable for forming pharmaceutically or physiologically acceptable acid addition salts include, by way of example and not limitation, citric acid, maleic acid, fumaric acid, succinic acid, lactic acid, tartaric acid, methanesulfonic acid, and the like.

Thus, pharmaceutically or physiologically acceptable acid addition salts with inorganic or organic acids may include, by way of example and not limitation, hydrochlorides, hydrobromides, phosphates, sulfates, citrates, maleates, fumarates, succinates, lactates, tartrates, methanesulfonates (mesylates), and the like.

Salts which are unsuitable for pharmaceutical uses but which can be employed, for example, for the isolation or purification of free compounds of formula (I) or their pharmaceutically acceptable salts, are also included.

Pharmaceutically non-acceptable salts, which can be obtained, for example, as process products during the preparation of the compounds according to this invention e.g. on an industrial scale, are converted into pharmaceutically acceptable salts by processes known to the person skilled in the art.

All isomeric forms (especially all regio- and stereoisomeric forms, e.g. all chiral, enantiomeric, diastereomeric, racemic forms, tautomeric and all geometric isomeric forms) of a compound of formula (I) are intended within this invention, unless the specific isomer form is specifically indicated. Obviously, the isomer which is pharmacologically most effective and most free from side effects is preferred.

It will be appreciated that the compounds of the present invention contain at least one, two or more asymmetrically

substituted carbon atoms, and may be isolated as pure diastereomers or diastereomeric mixtures in optically active or racemic forms.

The invention contemplates all conceivable stereoisomers, particularly the diastereomers and enantiomers mentioned herein, e.g. in substantially pure form, in enriched form (e.g. substantially free of any or all other undesired diastereomers and/or enantiomers) and/or in any mixing ratio, including the racemic forms, as well as the salts thereof.

In general, substantially pure stereoisomers can be obtained according to synthetic principles customary to the skilled person, e.g. by separation of corresponding mixtures, by using stereochemically pure starting materials and/or by stereoselective synthesis.

It is known in the art how to prepare optically active forms, such as by resolution of racemic forms or by synthesis, e.g. from optically active starting materials and/or by using chiral reagents.

Enantiomerically pure compounds of this invention can be prepared via asymmetric synthesis, for example by preparation and separation of appropriate diastereoisomeric compounds/intermediates which can be separated by known methods (e.g. by chromatographic separation or (fractional) crystallization from a suitable solvent), and/or by using chiral reaction components (e.g. chiral reagents, chiral catalysts, chiral ligands, chiral synthons, chiral building blocks, or the like).

Further, it is known to the person skilled in the art how to prepare enantiomerically pure compounds from the corresponding racemic mixtures, such as e.g. by chromatographic separation of the corresponding racemic compounds on chiral separating columns; or by resolution of racemic compounds using an appropriate resolving agent; e.g. by means of diastereomeric salt formation of the racemic compounds with optically active acids or bases, subsequent resolution of the salts and release of the desired compound from the salt; or by derivatization of the corresponding racemic compounds with chiral auxiliary reagents, subsequent diastereomer separation and removal of the chiral auxiliary group; by kinetic resolution of a racemate (e.g. by enzymatic resolution); by enantioselective (preferential) crystallization (or crystallization by entrainment) from a conglomerate of enantiomorphous crystals under suitable conditions; or by (fractional) crystallization from a suitable solvent in the presence of a chiral auxiliary.

The compounds of formula (I) obtained may be separated into the enantiomers and/or diastereomers thereof. For example, cis-/trans mixtures may be separated into their cis and trans isomers, and compounds with at least one optically active carbon atom may be resolved into their enantiomers.

Thus, for example, cis-/trans mixtures obtained may be separated by chromatography into their cis and trans isomers and the compounds of formula (I) obtained which occur as racemates may be separated by methods known per se (cf. Allinger N. L. and Eliel E. L. in "Topics in Stereochemistry", Vol. 6, Wiley Interscience, 1971) into their optical antipodes. Compounds of formula (I) with at least 2 asymmetric carbon atoms may be resolved into their diastereomers on the basis of their physical-chemical differences using methods known per se, e.g. by chromatography and/or fractional crystallisation, and, if these compounds are obtained in racemic form, they may subsequently be resolved into the enantiomers as mentioned above.

The enantiomers are preferably separated by column separation on chiral phases or by recrystallisation from an optically active solvent or by reacting with an optically active substance which forms salts or derivatives such as e.g. esters or amides with the racemic compound, particularly acids and the activated derivatives or alcohols thereof, and separating the diastereomeric mixture of salts or derivatives thus obtained, e.g. on the basis of their differences in solubility, whilst the free antipodes may be released from the pure diastereomeric salts or derivatives by the action of suitable agents. Optically active acids in common use are e.g. the D- and L-forms of tartaric acid or dibenzoyltartaric acid, di-o-tolyltartaric acid, malic acid, mandelic acid, camphorsulphonic acid, glutamic acid, aspartic acid or quinic acid. An optically active alcohol may be, for example, (+) or (−)-menthol and an optically active acyl group in amides, for example, may be a (+)- or (−)-menthyloxycarbonyl.

Those skilled in the art will appreciate that organic compounds or their salts can be isolated in association with solvent molecules or can form complexes with solvents with which they are contacted, in which they are reacted or from which they are isolated (e.g. precipitated, crystallized, lyophilized, etc.) or the like. According to expert's awareness, some of the compounds according to this invention (such as e.g. compounds of formulae (I), (II) or (II'), the tautomers, enantiomers, diastereomers, mixtures or salts thereof) may contain, e.g. when obtained or isolated in solid form, varying or fixed amounts of solvents (including aqueous and/or non-aqueous solvents). Included within the scope of the invention are therefore solvates (including hydrates, organic solvates and mixed hydrates/organic solvates) of the compounds according to this invention. Solvates of the compounds according to this invention may include stoichiometric or non-stoichiometric solvates, tightly or weakly bound solvates, as well as homo- or heterosolvates. Preferably the solvent(s) used is a pharmaceutically acceptable solvent(s), e.g. water and/or a low molecular weight aliphatic alcohol such as ethanol or the like. In an embodiment, solvates of the compounds of this invention may include, for example, hydrates or alcoholates, or mixed hydrates/alcoholates. The present invention embraces both the unsolvated and all solvated forms. Likewise, the present invention embraces any solvate, ansolvate, hydrate, anhydrous, hygroscopic and/or non-hygroscopic forms.

The compounds of formula (II) used as starting materials are either known from the literature or are obtained by methods such as those described for example in WO 04/018468, WO 04/050658, WO 05/085246, WO 06/029769 or WO 06/048427, or WO 2007/071738, WO 2008/017670, WO 2012/088682 or WO 2012/089127.

The compounds of formula (I) according to the invention and the physiologically acceptable salts thereof have valuable (in-vivo and in-vitro) pharmacological properties, particularly an inhibiting effect on the enzyme DPP-IV. The ability of the substances including their salts to inhibit the DPP-IV activity may be demonstrated in an experiment as described herein.

The DPP-IV assay may be carried out as follows:

Blood is taken from up to 4 human donors having no pharmacological therapy for the last 14 days via venous puncture in EDTA precoated tubes (Sarstedt, 2.6 ml Monovette). Blood samples are centrifuged at 4° C. at 800 rpm and finally supernatant was taken and used as EDTA plasma.

The 96-well plates are purchased from Greiner bio-one, CatNo 655900 (black, flat bottom). The substrate H-Ala-Pro-7-amido-4-trifluoromethylcoumarin (AlaPro-AFC) is from Bachem (Prod.-No1-1680). All other materials are of highest grade commercially available. EDTA-plasma is diluted 1:42.5 with assay buffer (100 mM Tris, 100 mM NaCl, adjusted to pH 7.8 with HCl). The final dilution of the plasma in the assay is 140 fold. In the 96-well plates 20 μL test

substance in assay buffer (final DMSO concentration 1%) are mixed with 50 µL substrate (200 mM stock solution in DMF (dimethylformamide), diluted 1:1000 with water, final concentration 100 µM) and 30 µL of diluted plasma. The plate is then incubated at room temperature for 1 hour and fluorescence of the wells is determined using a Wallac, Victor™ 1420 Multilabel Counter, at an Excitation wavelength of 405 nm and an Emission wavelength of 535 nm.

Each assay microtiter plate contains wells with vehicle controls (1% DMSO in assay buffer) as reference for non-inhibited enzyme activity and wells with assay buffer instead of enzyme as controls for background fluorescence. Background fluorescence is negligible.

The potency of the test substance in question, expressed as the IC50 value, is calculated from dosage/activity curves consisting of about 10 measured points in each case.

The following results are obtained:

Compound (Example no.)	DPP-IV inhibition IC50 [pM]
1	6

In view of their ability to inhibit DPP-IV activity, the compounds of formula (I) according to the invention and the corresponding pharmaceutically acceptable salts thereof are suitable for influencing any conditions or disorders which can be affected by the inhibition of the DPP-IV activity. It is therefore to be expected that the compounds according to the invention will be suitable for the prevention or treatment of diseases or conditions such as type I and type II diabetes mellitus, prediabetes, reduced glucose tolerance or changes in the fasting blood sugar, diabetic complications (e.g. retinopathy, nephropathy or neuropathies), metabolic acidosis or ketosis, reactive hypoglycaemia, insulin resistance, metabolic syndrome, dyslipidaemias of various origins, arthritis, atherosclerosis and related diseases, obesity, allograft transplantation and osteoporosis caused by calcitonin. In addition, these substances are suitable for preventing B-cell degeneration such as e.g. apoptosis or necrosis of pancreatic B-cells. The substances are also suitable for improving or restoring the function of pancreatic cells and additionally increasing the size and number of pancreatic B-cells. Additionally, on the basis of the role of the glucagon-like peptides such as e.g. GLP-1 and GLP-2 and their link with DPP-IV inhibition, it is expected that the compounds according to the invention will be suitable for achieving a sedative or tranquillising effect, as well as having a favourable effect on catabolic states after operations or hormonal stress responses or possibly reducing mortality and morbidity after myocardial infarction. Moreover, they are suitable for treating any conditions connected with the effects mentioned above and mediated by GLP-1 or GLP-2. The compounds according to the invention may also be used as diuretics or antihypertensives and are suitable for preventing and treating acute kidney failure. The compounds according to the invention may also be used to treat inflammatory complaints of the respiratory tract. They are also suitable for preventing and treating chronic inflammatory bowel diseases such as e.g. irritable bowel syndrome (IBS), Crohn's disease or ulcerative colitis and also pancreatitis. It is also expected that they can be used for all kinds of injury or damage to the gastrointestinal tract such as may occur in colitis and enteritis, for example. Moreover, it is expected that DPP-IV inhibitors and hence the compounds according to the invention can be used to treat infertility or to improve fertility in humans or mammals, particularly if the infertility is connected with insulin resistance or with polycystic ovary syndrome. On the other hand these substances are suitable for influencing sperm motility and are thus suitable for use as male contraceptives. In addition, the substances are suitable for treating growth hormone deficiencies connected with restricted growth, and may reasonably be used for all indications for which growth hormone may be used. The compounds according to the invention are also suitable, on the basis of their inhibitory effect on DPP-IV, for treating various autoimmune diseases such as e.g. rheumatoid arthritis, multiple sclerosis, thyroiditis and Basedow's disease, etc. They may also be used to treat viral diseases and also, for example, in HIV infections, for stimulating blood production, in benign prostatic hyperplasia, gingivitis, as well as for the treatment of neuronal defects and neurodegenerative diseases such as Alzheimer's disease, for example. The compounds described may also be used for the treatment of tumours, particularly for modifying tumour invasion and also metastasisation; examples here are their use in treating T-cell lymphomas, acute lymphoblastic leukaemia, cell-based thyroid carcinomas, basal cell carcinomas or breast cancers. Other indications are stroke, ischaemia of various origins, Parkinson's disease and migraine. In addition, further indications include follicular and epidermal hyperkeratoses, increased keratinocyte proliferation, psoriasis, encephalomyelitis, glomerulonephritis, lipodystrophies, as well as psychosomatic, depressive and neuropsychiatric diseases of all kinds.

Accordingly, the present invention further relates to a compound of formula (I), or a tautomer or salt thereof, for use in the therapies described herein.

The present invention further relates to a pharmaceutical composition comprising a compound of formula (I), or a tautomer or salt thereof, and, optionally, one or more pharmaceutically acceptable excipients.

The present invention further relates to a combination or composition comprising a compound of formula (I), or a tautomer or salt thereof, and one or more other active substances selected from those mentioned herein, e.g. selected from other antidiabetic substances, active substances that lower the blood sugar level, active substances that lower the lipid level in the blood, active substances that raise the HDL level in the blood, active substances that lower blood pressure, and active substances that are indicated in the treatment of atherosclerosis or obesity, e.g. each as described herein; particularly for simultaneous, separate or sequential use in the therapies described herein.

The present invention further relates to a pharmaceutical composition comprising a compound of formula (I), or a tautomer or salt thereof, and another agent or substance, such as e.g. in free or salt form (e.g. in an acid addition salt form), and, optionally, one or more pharmaceutically acceptable excipients.

The present invention further relates to a pharmaceutical composition comprising a compound of formula (I), or a tautomer or salt thereof, and metformin (e.g. metformin hydrochloride), and, optionally, one or more pharmaceutically acceptable excipients.

The present invention further relates to a pharmaceutical composition comprising a compound of formula (I), or a tautomer or salt thereof, and pioglitazone (e.g. pioglitazone hydrochloride), and, optionally, one or more pharmaceutically acceptable excipients.

The present invention further relates to a compound of formula (I), or a tautomer or salt thereof, or a composition thereof, in combination with metformin (e.g. metformin hydrochloride), for use in the therapies described herein.

The present invention further relates to a compound of formula (I), or a tautomer or salt thereof, or a composition thereof, in combination with pioglitazone (e.g. pioglitazone hydrochloride), for use in the therapies described herein.

The present invention further relates to a compound of formula (I), or a tautomer or salt thereof, or a composition thereof, in combination with telmisartan, for use in the therapies described herein.

The present invention further relates to a method for treating and/or preventing metabolic diseases, especially type 2 diabetes mellitus and/or conditions related thereto (e.g. diabetic complications) comprising the combined (e.g. simultaneous, separate or sequential) administration of one or more other antidiabetics selected from the group consisting of metformin, a sulphonylurea, nateglinide, repaglinide, a thiazolidinedione (e.g. pioglitazone), a PPAR-gamma-agonist, an alpha-glucosidase inhibitor, insulin or an insulin analogue, and GLP-1 or a GLP-1 analogue, and a compound of formula (I), a tautomer or salt thereof, or composition thereof, to the patient (particularly human patient) in need thereof.

Examples of such metabolic disorders or diseases amenable by the therapy of this invention, particularly in the patients described herein, may include, without being limited to, type 1 diabetes, type 2 diabetes, latent autoimmune diabetes in the adult (LADA), impaired glucose tolerance (IGT), impaired fasting blood glucose (IFG), hyperglycemia, postprandial hyperglycemia, postabsorptive hyperglycemia, overweight, obesity, dyslipidemia, hyperlipidemia, hypercholesterolemia, hypertriglyceridemia, hypertension, atherosclerosis, endothelial dysfunction, osteoporosis, chronic systemic inflammation, non alcoholic fatty liver disease (NAFLD), retinopathy, neuropathy, nephropathy, polycystic ovarian syndrome, and/or metabolic syndrome.

The present invention further relates to at least one of the following methods:

- preventing, slowing the progression of, delaying or treating a metabolic disorder or disease, such as e.g. type 1 diabetes mellitus, type 2 diabetes mellitus, latent autoimmune diabetes in the adult (LADA), impaired glucose tolerance (IGT), impaired fasting blood glucose (IFG), hyperglycemia, postprandial hyperglycemia, postabsorptive hyperglycemia, overweight, obesity, dyslipidemia, hyperlipidemia, hypercholesterolemia, hypertriglyceridemia, hypertension, atherosclerosis, endothelial dysfunction, osteoporosis, chronic systemic inflammation, non alcoholic fatty liver disease (NAFLD), retinopathy, neuropathy, nephropathy, polycystic ovarian syndrome, and/or metabolic syndrome;
- improving and/or maintaining glycemic control and/or for reducing of fasting plasma glucose, of postprandial plasma glucose, of postabsorptive plasma glucose and/or of glycosylated hemoglobin HbA1c;
- preventing, slowing, delaying or reversing progression from pre-diabetes, impaired glucose tolerance (IGT), impaired fasting blood glucose (IFG), insulin resistance and/or from metabolic syndrome to type 2 diabetes mellitus;
- preventing, reducing the risk of, slowing the progression of, delaying or treating of complications of diabetes mellitus such as micro- and macrovascular diseases, such as nephropathy, micro- or macroalbuminuria, proteinuria, retinopathy, cataracts, neuropathy, learning or memory impairment, neurodegenerative or cognitive disorders, cardio- or cerebrovascular diseases, tissue ischaemia, diabetic foot or ulcus, atherosclerosis, hypertension, endothelial dysfunction, myocardial infarction, acute coronary syndrome, unstable angina pectoris, stable angina pectoris, peripheral arterial occlusive disease, cardiomyopathy, heart failure, heart rhythm disorders, vascular restenosis, and/or stroke;
- reducing body weight and/or body fat or preventing an increase in body weight and/or body fat or facilitating a reduction in body weight and/or body fat;
- preventing, slowing, delaying or treating the degeneration of pancreatic beta cells and/or the decline of the functionality of pancreatic beta cells and/or for improving, preserving and/or restoring the functionality of pancreatic beta cells and/or stimulating and/or restoring or protecting the functionality of pancreatic insulin secretion;
- preventing, slowing, delaying or treating non alcoholic fatty liver disease (NAFLD) including hepatic steatosis, non-alcoholic steatohepatitis (NASH) and/or liver fibrosis (such as e.g. preventing, slowing the progression, delaying, attenuating, treating or reversing hepatic steatosis, (hepatic) inflammation and/or an abnormal accumulation of liver fat);
- preventing, slowing the progression of, delaying or treating type 2 diabetes with failure to conventional antidiabetic mono- or combination therapy;
- achieving a reduction in the dose of conventional antidiabetic medication required for adequate therapeutic effect;
- reducing the risk for adverse effects associated with conventional antidiabetic medication (e.g. hypoglycemia or weight gain); and/or
- maintaining and/or improving the insulin sensitivity and/or for treating or preventing hyperinsulinemia and/or insulin resistance;
- in a patient in need thereof (such as e.g a patient as described herein, especially a type 2 diabetes patient),

said method comprising administering a compound of formula (I), or a tautomer or salt thereof, or composition thereof, optionally in combination with one or more other therapeutic substances as described herein, to the patient.

The compounds of formula (I) or their pharmaceutically acceptable salts can be used as medicaments, e.g. in the form of pharmaceutical compositions for enteral, parenteral or topical administration. They may be administered in any of the generally accepted modes of administration available in the art, e.g., perorally, e.g. in the form of tablets, coated tablets, dragees, hard and soft gelatine capsules, solutions, emulsions or suspensions, rectally, e.g. in the form of suppositories, parenterally (including intravenously), e.g. in the form of injection solutions or infusion solutions, or topically, e.g. in the form of ointments, creams or oils. Among the possible modes of administration, oral and intravenous delivery are preferred.

The pharmaceutical compositions according to this invention may typically contain at least one of the compounds of the invention in a total amount of from about 0.05 to 80 wt %, or from about 0.1 to 50 wt %, optionally together with pharmaceutically acceptable excipients.

For example, the amount of the compound of formula (I) according to this invention, or a tautomer or salt thereof, comprised in a dosage form or pharmaceutical composition according to this invention may be at least 0.1% to 0.5%, or at least 0.5% to 1.5%, or at least 1% to 3%, optionally in addition to one or more excipients.

The person skilled in the art is familiar with pharmaceutically acceptable excipients, such as e.g. diluents, carriers, binders, disintegrants, surfactants, lubricants, vehicles, auxiliaries, adjuvants and/or further additives which are known to

be suitable for preparing pharmaceutical compositions, on account of his/her expert knowledge.

As pharmaceutically acceptable excipients, usually any excipients known to be appropriate for pharmaceutical compositions come into consideration. Examples thereof include, but are not limited to, diluents, fillers, binders, disintegrants, lubricants, glidants, solvents, dispersants, emulsifiers, solubilizers, gel formers, ointment bases, antioxidants, preservatives, stabilizers, carriers, thickeners, complexing agents, buffers, pH regulators (e.g. to obtain neutral, alkaline or acidic formulations), permeation promoters, polymers, coating agents, propellants, tonicity adjusting agents, surfactants, colorants, flavorings, sweeteners and dyes.

In general, suitable carrier materials are not only inorganic carrier materials, but also organic carrier materials. Thus, e.g., lactose, starches (e.g. corn starch) or derivatives thereof, talc, silica, polyvinylpyrrolidones, stearic acid or its salts can be used as carrier materials for tablets, coated tablets, dragees and hard gelatine capsules. Suitable carrier materials for soft gelatine capsules are, e.g., vegetable oils, waxes, fats and semi-solid and liquid polyols. Suitable carrier materials for the production of solutions and syrups are, e.g., water, polyols, sucrose, invert sugar and the like. Suitable carrier materials for injection or infusion solutions are, e.g., water, alcohols, polyols, glycerol and vegetable oils. Suitable carrier materials for suppositories are, e.g., natural or hardened oils, waxes, fats and semi-liquid or liquid polyols or polyethylene glycols. Suitable carrier materials for topical preparations are glycerides, semi-synthetic and synthetic glycerides, hydrogenated oils, liquid waxes, liquid paraffins, liquid fatty alcohols, sterols, polyethylene glycols and cellulose derivatives.

In particular, excipients, carriers and/or diluents of a type appropriate to the desired pharmaceutical composition, formulation or preparation and the desired mode of administration are used.

The pharmaceutical compositions (e.g. tablets) according to the invention may be obtained, for example, by mixing one or more compounds of formula (I) or a pharmaceutically acceptable salt thereof with suitable excipients, for example known inert diluents, carriers, disintegrants, adjuvants, surfactants, binders and/or lubricants. The tablets may also consist of several layers. The compositions of this invention may also contain further active substances.

Accordingly, the pharmaceutical compositions according to this invention can be prepared by processes which are known per se and familiar to the person skilled in the art, e.g. by incorporating the described compounds of formula (I) or their pharmaceutically acceptable salts (optionally combined with other active substances) optionally together with one or more conventional carriers (e.g. solid or liquid carriers) and/or diluents, e.g. with corn starch, lactose, glucose, microcrystalline cellulose, magnesium stearate, polyvinylpyrrolidone, citric acid, tartaric acid, water, water/ethanol, water/glycerol, water/sorbitol, water/polyethylene glycol, propylene glycol, cetylstearyl alcohol, carboxymethylcellulose or fatty substances such as hard fat or suitable mixtures thereof, into conventional galenic preparations such as plain or coated tablets, capsules, powders, suspensions or suppositories.

The dosage of the compounds of the invention can vary within wide limits depending on the compound which is to be administered, the nature and gravity of the disease to be treated or prevented, the age and the individual condition of the patient and the mode and frequency of administration, and will, of course, be fitted to the individual requirements in each particular case. Usually, a dosage of the compounds of the invention in the order of magnitude customary for DPP-IV inhibitors comes into consideration.

The dosage typically required for compounds of this invention, when administered by intravenous route, may be 0.001 mg to 10 mg, or 0.01 mg to 10 mg, or 0.1 mg to 10 mg, such as e.g. 0.25 mg to 5 mg, and, when administered by oral route, may be 0.005 mg to 100 mg, or 0.05 mg to 100 mg, or 0.5 mg to 100 mg, such as e.g. 2.5 mg to 50 mg or 0.5 mg to 10 mg, preferably 2.5 mg to 10 mg or 1 mg to 5 mg, in each case 1 to 4 times a day. Depending on the dosage it may be convenient to administer the daily dosage in several dosage units.

A dosage form containing a pharmaceutical composition according to this invention may typically comprise the compound of formula (I) according to this invention, or a tautomer or salt thereof, in a dosage range from about 0.1 mg to 100 mg.

Accordingly, the pharmaceutical compositions according to this invention comprising the compounds of this invention are prepared by the skilled person using pharmaceutically acceptable formulation excipients as described in the art and appropriate for the desired route of administration.

Oral preparations or dosage forms of the compounds of this invention may be prepared according to known techniques.

Examples of suitable diluents for compounds according to this invention may include cellulose powder, calcium hydrogen phosphate, erythritol, low substituted hydroxypropyl cellulose, mannitol, pregelatinized starch or xylitol.

Examples of suitable lubricants for compounds according to this invention may include talc, polyethyleneglycol, calcium behenate, calcium stearate, hydrogenated castor oil or magnesium stearate.

Examples of suitable binders for compounds according to this invention may include copovidone (copolymerisates of vinylpyrrolidon with other vinylderivates), hydroxypropyl methylcellulose (HPMC), hydroxypropylcellulose (HPC), polyvinylpyrrolidon (povidone), pregelatinized starch, or low-substituted hydroxypropylcellulose (L-HPC).

Examples of suitable disintegrants for compounds according to this invention may include corn starch or crospovidone.

Suitable methods of preparing pharmaceutical formulations of the DPP-IV inhibitors according to the invention may be

- direct tabletting of the active substance in powder mixtures with suitable tabletting excipients;
- granulation with suitable excipients and subsequent mixing with suitable excipients and subsequent tabletting as well as film coating; or
- packing of powder mixtures or granules into capsules.

Suitable granulation methods may be

- wet granulation in the intensive mixer followed by fluidised bed drying;
- one-pot granulation;
- fluidised bed granulation; or
- dry granulation (e.g. by roller compaction) with suitable excipients and subsequent tabletting or packing into capsules.

An illustrative composition (e.g. tablet core) of a compound according to the invention may comprise the first diluent mannitol, pregelatinized starch as a second diluent with additional binder properties, the binder copovidone, the disintegrant corn starch, and magnesium stearate as lubricant; wherein copovidone and/or corn starch may be optional.

A tablet of a compound according to the invention may be film coated, preferably the film coat comprises hydroxypropylmethylcellulose (HPMC), polyethylene glycol (PEG) or propylene glycol (PG), talc, titanium dioxide and iron oxide (e.g. red and/or yellow).

The pharmaceutical compositions (or formulations) may be packaged in a variety of ways. Generally, an article for distribution includes one or more containers that contain the

one or more pharmaceutical compositions in an appropriate form. Tablets are typically packed in an appropriate primary package for easy handling, distribution and storage and for assurance of proper stability of the composition at prolonged contact with the environment during storage. Primary containers for tablets may be bottles or blister packs.

A suitable bottle, e.g. for a pharmaceutical composition or combination (tablet) comprising a compound according to the invention, may be made from glass or polymer (preferably polypropylene (PP) or high density polyethylene (HD-PE)) and sealed with a screw cap. The screw cap may be provided with a child resistant safety closure (e.g. press-and-twist closure) for preventing or hampering access to the contents by children. If required (e.g. in regions with high humidity), by the additional use of a desiccant (such as e.g. bentonite clay, molecular sieves, or, preferably, silica gel) the shelf life of the packaged composition can be prolonged.

A suitable blister pack, e.g. for a pharmaceutical composition or combination (tablet) comprising a compound according to the invention, may comprise or formed of a top foil (which is breachable by the tablets) and a bottom part (which contains pockets for the tablets). The top foil may contain a metalic foil, particularly an aluminium or aluminium alloy foil (e.g. having a thickness of 20 μm to 45 μm, preferably 20 μm to 25 μm) that is coated with a heat-sealing polymer layer on its inner side (sealing side). The bottom part may contain a multi-layer polymer foil (such as e.g. poly (vinyl chloride) (PVC) coated with poly(vinylidene chloride) (PVDC); or a PVC foil laminated with poly(chlorotriflouroethylene) (PCTFE)) or a multi-layer polymer-metal-polymer foil (such as e.g. a cold-formable laminated PVC/aluminium/polyamide composition).

To ensure a long storage period especially under hot and wet climate conditions an additional overwrap or pouch made of a multi-layer polymer-metal-polymer foil (e.g. a laminated polyethylen/aluminium/polyester composition) may be used for the blister packs. Supplementary desiccant (such as e.g. bentonite clay, molecular sieves, or, preferably, silica gel) in this pouch package may prolong the shelf life even more under such harsh conditions.

The article may further comprise a label or package insert, which refer to instructions customarily included in commercial packages of therapeutic products, that may contain information about the indications, usage, dosage, administration, contraindications and/or warnings concerning the use of such therapeutic products. In one embodiment, the label or package inserts indicates that the composition can be used for any of the purposes described herein.

The DPP-IV inhibitors of this invention—besides their use in mono-therapy—may also be used in conjunction with other active substances, by means of which improved treatment results can be obtained. Such a combined treatment may be given as a free combination of the substances or in the form of a fixed combination, for example in a tablet or capsule. Pharmaceutical formulations of the combination partner needed for this may either be obtained commercially as pharmaceutical compositions or may be formulated by the skilled man using conventional methods. The active substances which may be obtained commercially as pharmaceutical compositions are described in numerous places in the prior art, for example in the list of drugs that appears annually, the "Rote Liste®" of the federal association of the pharmaceutical industry, or in the annually updated compilation of manufacturers' information on prescription drugs known as the "Physicians' Desk Reference".

Examples of antidiabetic combination partners are metformin; sulphonylureas such as glibenclamide, tolbutamide, glimepiride, glipizide, gliquidon, glibornuride and gliclazide; nateglinide; repaglinide; mitiglinide, thiazolidinediones such as rosiglitazone and pioglitazone; PPAR gamma modulators such as metaglidases; PPAR-gamma agonists such as mitoglitazone, INT-131, balaglitazone or rivoglitazone; PPAR-gamma antagonists; PPAR-gamma/alpha modulators such as tesaglitazar, muraglitazar, aleglitazar, indeglitazar and KRP297; PPAR-gamma/alpha/delta modulators such as e.g. lobeglitazone; AMPK-activators such as AICAR; acetyl-CoA carboxylase (ACC1 and ACC2) inhibitors; diacylglycerol-acetyltransferase (DGAT) inhibitors; pancreatic beta cell GCRP agonists such as GPR119 agonists (SMT3-receptor-agonists), such as the GPR119 agonists 5-ethyl-2-{4-[4-(4-tetrazol-1-yl-phenoxymethyl)-thiazol-2-yl]-piperidin-1-yl}-pyrimidine or 5-[1-(3-isopropyl-[1,2,4]oxadiazol-5-yl)-piperidin-4-ylmethoxy]-2-(4-methanesulfonyl-phenyl)-pyridine; 11β-HSD-inhibitors; FGF19 agonists or analogues; alpha-glucosidase blockers such as acarbose, voglibose and miglitol; alpha2-antagonists; insulin and insulin analogues such as human insulin, insulin lispro, insulin glusilin, r-DNA-insulinaspart, NPH insulin, insulin detemir, insulin degludec, insulin tregopil, insulin zinc suspension and insulin glargin; Gastric inhibitory Peptide (GIP); amylin and amylin analogues (e.g. pramlintide or davalintide); GLP-1 and GLP-1 analogues such as Exendin-4, e.g. exenatide, exenatide LAR, liraglutide, taspoglutide, lixisenatide (AVE-0010), LY-2428757 (a PEGylated version of GLP-1), dulaglutide (LY-2189265), semaglutide or albiglutide; SGLT2-inhibitors such as e.g. dapagliflozin, sergliflozin (KGT-1251), atigliflozin, canagliflozin or (1S)-1,5-anhydro-1-[3-(1-benzothiophen-2-ylmethyl)-4-fluorophenyl]-D-glucitol, ipragliflozin, tofogliflozin, luseogliflozin; inhibitors of protein tyrosine-phosphatase (e.g. trodusquemine); inhibitors of glucose-6-phosphatase; fructose-1,6-bisphosphatase modulators; glycogen phosphorylase modulators; glucagon receptor antagonists; phosphoenolpyruvatecarboxykinase (PEPCK) inhibitors; pyruvate dehydrogenasekinase (PDK) inhibitors; inhibitors of tyrosine-kinases (50 mg to 600 mg) such as PDGF-receptor-kinase (cf. EP-A-564409, WO 98/35958, U.S. Pat. No. 5,093,330, WO 2004/005281, and WO 2006/041976) or of serine/threonine kinases; glucokinase/regulatory protein modulators incl. glucokinase activators; glycogen synthase kinase inhibitors; inhibitors of the SH2-domain-containing inositol 5-phosphatase type 2 (SHIP2); IKK inhibitors such as high-dose salicylate; JNK1 inhibitors; protein kinase C-theta inhibitors; beta 3 agonists such as ritobegron, YM 178, solabegron, talibegron, N-5984, GRC-1087, rafabegron, FMP825; aldosereductase inhibitors such as AS 3201, zenarestat, fidarestat, epalrestat, ranirestat, NZ-314, CP-744809, and CT-112; SGLT-1 or SGLT-2 inhibitors; KV 1.3 channel inhibitors; GPR40 modulators such as e.g. [(3S)-6-({2',6'-dimethyl-4'-[3-(methylsulfonyl)propoxy]biphenyl-3-yl}methoxy)-2,3-dihydro-1-benzofuran-3-yl]acetic acid; SCD-1 inhibitors; CCR-2 antagonists; dopamine receptor agonists (bromocriptine mesylate [Cycloset]); 4-(3-(2,6-dimethylbenzyloxyl)phenyl)-4-oxobutanoic acid; sirtuin stimulants; and other DPP IV inhibitors.

Metformin is usually given in doses varying from about 500 mg to 2000 mg up to 2500 mg per day using various dosing regimens from about 100 mg to 500 mg or 200 mg to 850 mg (1-3 times a day), or about 300 mg to 1000 mg once or twice a day, or delayed-release metformin in doses of about 100 mg to 1000 mg or preferably 500 mg to 1000 mg once or twice a day or about 500 mg to 2000 mg once a day. Particular dosage strengths may be 250, 500, 625, 750, 850 and 1000 mg of metformin hydrochloride.

For children 10 to 16 years of age, the recommended starting dose of metformin is 500 mg given once daily. If this dose fails to produce adequate results, the dose may be increased to 500 mg twice daily. Further increases may be made in increments of 500 mg weekly to a maximum daily dose of 2000 mg, given in divided doses (e.g. 2 or 3 divided doses). Metformin may be administered with food to decrease nausea.

A dosage of pioglitazone is usually of about 1-10 mg, 15 mg, 30 mg, or 45 mg once a day.

Rosiglitazone is usually given in doses from 4 to 8 mg once (or divided twice) a day (typical dosage strengths are 2, 4 and 8 mg).

Glibenclamide (glyburide) is usually given in doses from 2.5-5 to 20 mg once (or divided twice) a day (typical dosage strengths are 1.25, 2.5 and 5 mg), or micronized glibenclamide in doses from 0.75-3 to 12 mg once (or divided twice) a day (typical dosage strengths are 1.5, 3, 4.5 and 6 mg).

Glipizide is usually given in doses from 2.5 to 10-20 mg once (or up to 40 mg divided twice) a day (typical dosage strengths are 5 and 10 mg), or extended-release glibenclamide in doses from 5 to 10 mg (up to 20 mg) once a day (typical dosage strengths are 2.5, 5 and 10 mg).

Glimepiride is usually given in doses from 1-2 to 4 mg (up to 8 mg) once a day (typical dosage strengths are 1, 2 and 4 mg).

A dual combination of glibenclamide/metformin is usually given in doses from 1.25/250 once daily to 10/1000 mg twice daily. (typical dosage strengths are 1.25/250, 2.5/500 and 5/500 mg).

A dual combination of glipizide/metformin is usually given in doses from 2.5/250 to 10/1000 mg twice daily (typical dosage strengths are 2.5/250, 2.5/500 and 5/500 mg).

A dual combination of glimepiride/metformin is usually given in doses from 1/250 to 4/1000 mg twice daily.

A dual combination of rosiglitazone/glimepiride is usually given in doses from 4/1 once or twice daily to 4/2 mg twice daily (typical dosage strengths are 4/1, 4/2, 4/4, 8/2 and 8/4 mg).

A dual combination of pioglitazone/glimepiride is usually given in doses from 30/2 to 30/4 mg once daily (typical dosage strengths are 30/4 and 45/4 mg).

A dual combination of rosiglitazone/metformin is usually given in doses from 1/500 to 4/1000 mg twice daily (typical dosage strengths are 1/500, 2/500, 4/500, 2/1000 and 4/1000 mg).

A dual combination of pioglitazone/metformin is usually given in doses from 15/500 once or twice daily to 15/850 mg thrice daily (typical dosage strengths are 15/500 and 15/850 mg).

The non-sulphonylurea insulin secretagogue nateglinide is usually given in doses from 60 to 120 mg with meals (up to 360 mg/day, typical dosage strengths are 60 and 120 mg); repaglinide is usually given in doses from 0.5 to 4 mg with meals (up to 16 mg/day, typical dosage strengths are 0.5, 1 and 2 mg). A dual combination of repaglinide/metformin is available in dosage strengths of 1/500 and 2/850 mg.

Acarbose is usually given in doses from 25 to 100 mg with meals. Miglitol is usually given in doses from 25 to 100 mg with meals.

Examples of combination partners that lower the lipid level in the blood are HMG-CoA-reductase inhibitors such as simvastatin, atorvastatin, lovastatin, fluvastatin, pravastatin, pitavastatin and rosuvastatin; fibrates such as bezafibrate, fenofibrate, clofibrate, gemfibrozil, etofibrate and etofyllinclofibrate; nicotinic acid and the derivatives thereof such as acipimox; PPAR-alpha agonists; PPAR-delta agonists such as e.g. {4-[(R)-2-ethoxy-3-(4-trifluoromethyl-phenoxy)-propylsulfanyl]-2-methyl-phenoxy}-acetic acid; inhibitors of acyl-coenzyme A:cholesterolacyltransferase (ACAT; EC 2.3.1.26) such as avasimibe; cholesterol resorption inhibitors such as ezetimib; substances that bind to bile acid, such as cholestyramine, colestipol and colesevelam; inhibitors of bile acid transport; HDL modulating active substances such as D4F, reverse D4F, LXR modulating active substances and FXR modulating active substances; CETP inhibitors such as torcetrapib, JTT-705 (dalcetrapib) or compound 12 from WO 2007/005572 (anacetrapib); LDL receptor modulators; MTP inhibitors (e.g. lomitapide); and ApoB100 antisense RNA.

A dosage of atorvastatin is usually from 1 mg to 40 mg or 10 mg to 80 mg once a day.

Examples of combination partners that lower blood pressure are beta-blockers such as atenolol, bisoprolol, celiprolol, metoprolol and carvedilol; diuretics such as hydrochlorothiazide, chlortalidon, xipamide, furosemide, piretanide, torasemide, spironolactone, eplerenone, amiloride and triamterene; calcium channel blockers such as amlodipine, nifedipine, nitrendipine, nisoldipine, nicardipine, felodipine, lacidipine, lercanipidine, manidipine, isradipine, nilvadipine, verapamil, gallopamil and diltiazem; ACE inhibitors such as ramipril, lisinopril, cilazapril, quinapril, captopril, enalapril, benazepril, perindopril, fosinopril and trandolapril; as well as angiotensin II receptor blockers (ARBs) such as telmisartan, candesartan, valsartan, losartan, irbesartan, olmesartan, azilsartan and eprosartan.

A dosage of telmisartan is usually from 20 mg to 320 mg or 40 mg to 160 mg per day.

Examples of combination partners which increase the HDL level in the blood are Cholesteryl Ester Transfer Protein (CETP) inhibitors; inhibitors of endothelial lipase; regulators of ABC1; LXRalpha antagonists; LXRbeta agonists; PPAR-delta agonists; LXRalpha/beta regulators, and substances that increase the expression and/or plasma concentration of apolipoprotein A-I.

Examples of combination partners for the treatment of obesity are sibutramine; tetrahydrolipstatin (orlistat); alizyme (cetilistat); dexfenfluramine; axokine; cannabinoid receptor 1 antagonists such as the CB1 antagonist rimonobant; MCH-1 receptor antagonists; MC4 receptor agonists; NPY5 as well as NPY2 antagonists (e.g. velneperit); beta3-AR agonists such as SB-418790 and AD-9677; 5HT2c receptor agonists such as APD 356 (lorcaserin); myostatin inhibitors; Acrp30 and adiponectin; steroyl CoA desaturase (SCD1) inhibitors; fatty acid synthase (FAS) inhibitors; CCK receptor agonists; Ghrelin receptor modulators; Pyy 3-36; orexin receptor antagonists; and tesofensine; as well as the dual combinations bupropion/naltrexone, bupropion/zonisamide, topiramate/phentermine and pramlintide/meterleptin.

Examples of combination partners for the treatment of atherosclerosis are phospholipase A2 inhibitors; inhibitors of tyrosine-kinases (50 mg to 600 mg) such as PDGF-receptor-kinase (cf. EP-A-564409, WO 98/35958, U.S. Pat. No. 5,093, 330, WO 2004/005281, and WO 2006/041976); oxLDL antibodies and oxLDL vaccines; apoA-1 Milano; ASA; and VCAM-1 inhibitors.

In practicing the present invention, the compounds according to this invention may be administered in combination therapy separately, sequentially, simultaneously, concurrently or chronologically staggered with one or more further active substances, such as e.g. any of the therapeutic agents mentioned herein above as a combination partner.

In this context, the present invention further relates to a combination comprising a first active ingredient, which is at least one compound according to this invention, and a second

active ingredient, which is at least one of the active substances described above as a combination partner, for separate, sequential, simultaneous, concurrent or chronologically staggered use in therapy, particularly for treatment and/or prevention of metabolic diseases, such as e.g. any of those mentioned herein.

Further, this invention relates to the use of a compound according to this invention combined with at least one of the active substances described above as a combination partner, for preparing a pharmaceutical composition which is suitable for the treatment or prevention of diseases or conditions which may be affected by the inhibition of the DPP-IV activity, particularly one of the diseases, disorders or conditions listed above, more particularly metabolic diseases.

Further, this invention relates to a pharmaceutical composition which comprises a compound according to the invention and at least one of the active substances described above as combination partners, optionally together with one or more inert carriers and/or diluents.

The term "combination" according to this invention may be present as a fixed combination, a non-fixed combination, a free combination or a kit-of-parts.

A "fixed combination" is defined as a combination wherein the said first active ingredient and the said second active ingredient are present together in one unit dosage or in a single entity. One example of a "fixed combination" is a pharmaceutical composition wherein the said first active ingredient and the said second active ingredient are present in admixture for simultaneous administration. Another example of a "fixed combination" is a pharmaceutical combination wherein the said first active ingredient and the said second active ingredient are present in one unit without being in admixture.

A "kit-of-parts" is defined as a combination wherein the said first active ingredient and the said second active ingredient are present in more than one unit. One example of a "kit-of-parts" is a combination wherein the said first active ingredient and the said second active ingredient are present separately. The components of the kit-of-parts may be administered separately, sequentially, simultaneously, concurrently or chronologically staggered.

The first and second active ingredient of a kit-of-parts according to this invention may be provided as separate formulations (i.e. independently of one another), which are subsequently brought together for simultaneous, concurrent, sequential, separate or chronologically staggered use in combination therapy; or packaged and presented together as separate components of a combination pack for simultaneous, concurrent, sequential, separate or chronologically staggered use in combination therapy.

The type of pharmaceutical formulation of the first and second active ingredient of a kit-of-parts according to this invention can be similar, i.e. both ingredients are formulated in separate tablets or capsules, or can be different, i.e. suited for different administration forms, such as e.g. one active ingredient is formulated as tablet or capsule and the other is formulated for e.g. intravenous administration.

The amounts of the first and second active ingredients of the combinations, compositions or kits according to this invention may together comprise a therapeutically effective amount, particularly for the treatment and/or prevention of the diseases, disorders and conditions mentioned above.

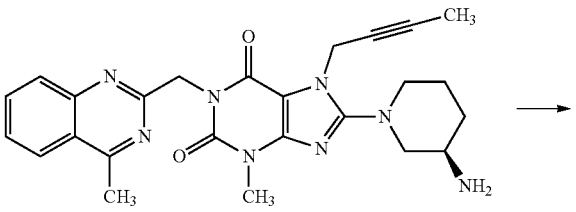
The present invention is not to be limited in scope by the specific embodiments described herein. Various modifications of the invention in addition to those described herein may become apparent to those skilled in the art from the present disclosure. Such modifications are intended to fall within the scope of the appended claims.

All patent applications cited herein are hereby incorporated by reference in their entireties. Further embodiments, features and advantages of the present invention may become apparent from the following examples. The following examples serve to illustrate, by way of example, the principles of the invention without restricting it.

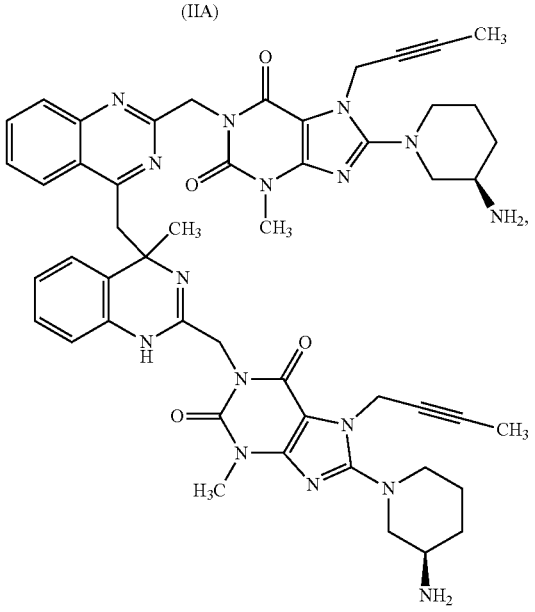
EXAMPLES

Example 1

1H-purine-2,6-dione, 8-[(3R)-3-amino-1-piperidinyl]-1-[[4-[[2-[[8-[(3R)-3-amino-1-piperidinyl]-7-(2-butynyl)-2,3,6,7-tetrahydro-3-methyl-2,6-dioxo-1H-purin-1-yl]methyl]-1,4-dihydro-4-methyl-4-quinazolinyl]methyl]-2-quinazolinyl]methyl]-7-(2-butynyl)-3,7-dihydro-3-methyl



(IIA)



(IA)

10.0 g (21.2 mmol) 1H-Purine-2,6-dione, 8-[(3R)-3-amino-1-piperidinyl]-7-(2-butyn-1-yl)-3,7-dihydro-3-methyl-1-[(4-methyl-2-quinazolinyl)methyl] of formula (IIA) are suspended in 30 mL aqueous hydrochloric acid (4N) and stirred over night at room temperature. Afterwards, 30 mL aqueous sodium hydroxide solution (4N) are added. The precipitate is separated and dissolved in dichloromethane. After drying of the organic phase and removal of the solvent, the remaining residue is purified by column chromatography over silica gel and the respective fractions are combined.

Method: column: diameter=8 cm, length=25 cm; silica gel: 35-70 micron (DAVISIL™),

Eluent:

CH_2Cl_2/MeOH/NH_4OH=90/10/0.25 (0.5 L)

CH_2Cl_2/MeOH/NH_4OH=40/10/0.25 (0.5 L)

CH_2Cl_2/MeOH/NH_4OH=20/30/0.25 (0.5 L)

MeOH/NH_4OH=500:1 (1 L)

TLC: silica gel 60 F254, CH_2Cl_2/MeOH/NH_4OH=4/1/0.1, R_f=0.48

NH_4OH stands for concentrated aqueous ammonia. The ratio of the eluent components refer to volume units.

Yield: 4.95 g (25% of theory) of title compound of formula (IA)

$C_{50}H_{56}N_{16}O_4$ (945.09)

MS: [M+H]+=945

Example 2

Tablets

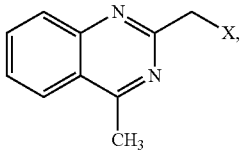
Copovidone is dissolved in purified water at ambient temperature to produce a granulation liquid. A DPP-IV inhibitor (active ingredient), mannitol, pregelatinized starch and corn starch are blended in a suitable mixer, to produce a pre-mix. The pre-mix is moistened with the granulation liquid and subsequently granulated e.g. using a high shear mixer. The moist granulate is optionally sieved through a suitable sieve (e.g. with a mesh size of 1.6-3.0 mm). The granulate is dried at about 60° C. inlet air temperature in a fluid bed dryer until a loss on drying value of 1-4% or 2-4% is obtained. The dried granulate may be sieved through a sieve with a mesh size of 1.0 mm. Magnesium stearate is passed through a sieve for delumping and added to the granulation. Subsequently a final blend is produced by final blending in a suitable blender. The final blend is compressed into tablet cores.

Optionally the tablet cores may be film-coated: Hydroxypropyl methylcellulose, polyethylene glycol, talc, titanium dioxide and iron oxide are suspended in purified water in a suitable mixer at ambient temperature to produce a coating suspension. The tablet cores are coated with the coating suspension to a weight gain of about 3% to produce film-coated tablets. The following tablet compositions can be obtained:

Component	mg	mg	mg	mg	mg
Active ingredient	0.500	1.000	2.500	5.000	10.000
Mannitol	67.450	66.950	65.450	130.900	125.900
Pregelatinized starch	9.000	9.000	9.000	18.000	18.000
Corn starch	9.000	9.000	9.000	18.000	18.000
Copovidone	2.700	2.700	2.700	5.400	5.400
Magnesium stearate	1.350	1.350	1.350	2.700	2.700
Total Mass (tablet core)	90.000	90.000	90.000	180.000	180.000
HPMC	1.500	1.500	1.500	2.500	2.500
PEG	0.150	0.150	0.150	0.250	0.250
Titanium dioxide	0.750	0.750	0.750	1.250	1.250
Talc	0.525	0.525	0.525	0.875	0.875
Iron oxide	0.075	0.075	0.075	0.125	0.125
Total Mass (coated tablet)	93.000	93.000	93.000	185.000	185.000

The invention claimed is:

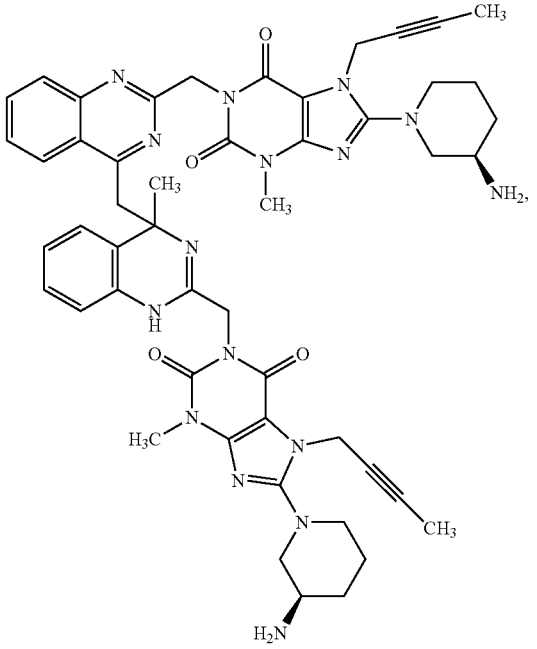
1. A method for preparing a compound of formula (II) or a salt thereof,



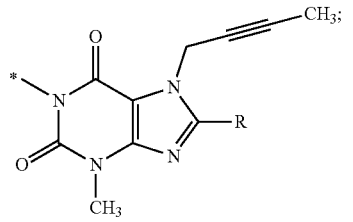
(II)

comprising dissociating a compound of formula (IA)

(IA)



or a tautomer, enantiomer, diastereomer, mixture or salt thereof,
into a compound of formula (II) or a salt thereof, wherein
X is a group of formula



and R is 3-(R)-amino-piperidin-1-yl.

2. The method according to claim **1**, further comprising
(a) carrying out the dissociation of the compound of formula (IA) in a suitable solvent or mixture of solvents, and
(b) isolating the obtained compound of formula (II) from the suitable solvent or mixture of solvents.

3. The method according to claim **2**, wherein the solvent or solvent system comprises one or more solvents selected from

the group consisting of ketones, lactones, ethers, hydrocarbons, chlorinated hydrocarbons, low-molecular-weight aliphatic alcohols, esters, amides or lactames, nitriles, sulfoxides, amines, and water; or a mixture thereof.

4. The method according to claim **3**, wherein the solvent is a polar solvent or mixture of polar solvents.

5. The method according to claim **3**, wherein the solvent or solvent system comprises a low-molecular-weight aliphatic alcohol.

6. The method according to claim **3**, wherein the solvent is water or an aqueous medium.

7. The method according to claim **2**, wherein the compound of formula (II) or a salt thereof is obtained in crystalline, amorphous, lyophilized or dried form.

8. The method according to claim **1**, which is conducted in the presence of an acid.

9. The method according to claim **8**, wherein the acid is HCl.

10. The method according to claim **8**, wherein the acid is aqueous hydrochloric acid.

* * * * *